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Evaluation of a Survey Technique to Detect Mortality Caused by Root Diseases and Bark Beetles on the San Juan National Forest, 1982

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INTRODUCTION

During the summer of 1982, a multi-stage, multi-phase survey using aerial photography and ground survey was evaluated on the San Juan National Forest to estimate losses of subalpine fir (Abies lasiocarpa (Hook.) Nutt.) to root diseases. This evaluation was initiated to develop a technique that could be applied regionwide to assess root-disease caused losses for the major commercial tree species. The importance of the spruce-fir forests has led to estimates of volume losses to wood-decay fungi (Hinds, et al 1960; Hinds and Hawksworth, 1966; Hornibrook, 1950); however, knowledge of root disease fungi is lacking. Previous investigations have indicated that many bark-beetle attacked trees also are infested with root disease organisms (James and Goheen, 1981). The primary root pathogens appear to be Heterobasidion annosum (Fr.) Bref. (= Fomes annosus) and Armillaria mellea (Vahl.:Fr.) Quel. (Johnson, 1984). The most serious insect on subalpine fir is the western balsam bark beetle (Dryocoetes confusus Swaine).

METHODS AND MATERIALS

Survey Area

The survey was confined to the spruce-fir type on the San Juan National Forest and encompassed 363,300 acres. State and privately owned lands and other dedicated lands were also included. All designated wilderness areas within the spruce-fir type were excluded from the survey.

Survey Design

The survey was a multi-stage, multi-phase design using aerial photography and ground survey (Lister and Young, 1981; White et al. 1983). First-stage sampling systematically selected photo plots using current forest type maps and a grid overlay. Large-scale (1:5,000) aerial photographs of each photo plot were interpreted for mortality (red-colored tree crowns) within 90-acre (36.4 ha.) plots. Sample photo plots were selected with probabilities proportional to size (pps) based on the number of red trees within the 90 acre photo plots (Cochran, 1977). Subsequently, each 90-acre photo plot was divided into 36, 2.5 acre (1 ha.) subplots. Ground truth sample plots were selected from the 2.5 acre subplots using pps based on mortality counts of each subplot. Ground data collected in these plots was used to correct estimates of cumulative mortality and volume loss by pest, and extent of survey area occupied by root disease.

Strata Delineation and Photo Plot Selection

Survey strata was defined as all lands within the San Juan National Forest which consisted of 51% or greater composition of spruce and subalpine fir. These acreages were delineated using USDA forest type maps. All federal and state-owned lands, and all dedicated mineral claims were included in the survey. Only wilderness areas were excluded.

Photo plot selection was determined using an equal area grid based on the following formula:

$$I = \sqrt{\frac{\text{(acres in strata/640)}}{\text{No. of photo plots desired}}} \times \text{(map scale in inches per mile)}$$

where: I equals distance, in inches, between grid points.

The number of photo plots necessary to give statistical accuracy is generally agreed to be between 100-200 plots per strata. It was determined that 175 photo plots were needed for this survey. It was felt that by the time plots were selected, photographed, and interpreted, many plots would be discarded from sampling for various reasons (incorrect location, non-type, timber harvested since type mapped, etc.).

Using the previous formula, an acetate overlay was prepared with a grid spacing of 3.6 inches. The acetate was placed over the type map using a random start, and all grid intersections which fell over a spruce-fir stand were designated as photo plots. Using this method, 169 potential photo plots were selected. If a large discrepancy had existed between the number of plots allocated (175) and those actually selected (164), it would have indicated the area calculations (363,200 acres) or the grid spacing (3.6 inches) were in error. This would have necessitated a review of selection procedures and calculations.

Photo Acquisition

Photography was acquired using a B-80 twin engine Queen Air equipped with a Zeiss RMK $^{21}/_{23}$ camera with a focal length of 8 1/4 inches. The Rocky Mountain Region provided the pilot (Ron Bell) and the Methods Application Group, Ft. Collins, provided the camera operator (Richard Myhre). A high-speed, color reversal film (Kodak Ektachrome EF aerographic (SO 397) with 4.0 ml ESTAR base and B-11 backing) was used. Desired photo scale was 1:5,000. Flight altitude varied between 11,000 to 15,00 ft. (MSL). This altitude dictated camera settings of ASA160, f-stop 5.6, and average shutter speed of 1/500. Plots were photographed as stereo triplets with 70 percent forward overlap.

The photomission was flown from July 5, 1982 to July 10, 1982. Actual flight time was 18.1 hours (including aircraft ferry time). The daily flight window was from 1000-1400. On a good day, about 40 points could be photographed.

To assist the pilot in navigation from one photo point to another and to aid the camera operator in locating the desired plot through the cameras' forward-looking periscope, a reliable map was needed. All photo points were transferred from the forest type maps to contact prints of orthophotos of the survey area and 7.5 min. topographic maps using proportional dividers. Forty-four orthophotos were necessary to cover the survey area. Two sets of the orthophotos were prepared. One set was for the camera operator, the other set for the pilot. This map had north-south and east-west lines drawn over photo plots to aid the pilot in his photo plot approach.

Photo Interpretation

After final adjustments, the total number of photo plots interpreted was 106 (total initially selected - 169). The 63 remaining plots were not photographed because of adverse weather conditions and aircraft availability. The photography was handled in the following manner:

1. Ground plot identity was verified using the camera operators' notes and corresponding photo frame numbers.

2. Film strips were checked against 7.5 min. topographic quadrangle maps for proper photo plot locations. The plot center was located in the center photograph of stereo triplets.

3. Each photo frame was individually labelled with plot number and North direction.

4. The camera altimeter and 75 min. topographic map were used to determine aircraft altitude and plot center elevation. Each photograph was scaled using the following formula:

$$PSR = \frac{H-h}{f}$$

where: PSR = Photo Scale Reciprocal
H = flying height above MSL
h = elevation of plot above MSL
f = camera focal length (use 0.6832)

5. The scale closest to photo scale was selected. The plot grid was taped down, and plot corners were pricked through the grid and photo. The photo was then labelled with scale.

6. An Old Delft stereo viewer was used to tally current tree mortality in each 2.5-acre subplot.

7. Acres infested by root disease were determined in the following manner:
   a. Only those 2.5-acre subplots exhibiting current tree mortality were examined.

   b. Photos were viewed under a Vantage Com IV microfiche reader and clear acetate sheets were placed over the screen.

   c. Subplot (2.5-acre) corners were marked and areas of suspected root disease outlined on the acetate by using the nearest healthy trees as boundaries for the limits of the root disease centers. NOTE: In Colorado, we seldom see large disease centers thus it is necessary to include many healthy appearing trees within root disease boundaries. These boundaries represent acres infested by root disease, not acres "out of production" or acres of mortality.

   d. Using a digital planimeter, the percent of each 2.5-acre subplot suspected of containing root disease was determined.

Ground Plot Selection

Ground plots were selected using a two step method developed by White et al. 1983. During the first step, 90 acre photo plots were selected based on the mortality count over old photo plots. Secondly, one 2.5-acre subplot was selected within the photo plots. PPS was used as the selection criteria.

Ground Verification

Ground verification of selected subplots was accomplished using a 2-3 person crew. All available aids were used to locate the subplots in the field. The contact prints of the orthophoto quads proved to be invaluable. Because the orthoquads were actual photos of the Forest, and much more recent than Forest maps, it was easy to navigate in the field to the subplots. Once in the area, the crew established the most easily located plot corner. Boundaries were determined and marked with string and the subplot was inventoried in the following manner:

1. Using a field stereo viewer, one crew member navigated and accurately located all four plot corners. Running a compass line from corner to corner was not accurate enough for this type of survey.

2. One crew member followed the member with the photos stringing the plot boundary.

3. The third crew member measured one boundary length (2 adjacent boundaries if slope was greater than 20%). The distance measured was the horizontal distance from corner to corner, not the slope distance.

4. After three sides of the plot were established, the third crew member began 100 percent cruise of the 2.5 acre subplot.

5. When all four corners were established and boundaries delineated, all crew members assisted in the 100 percent cruise.

6. In extremely dense stands 1-chain wide strips were delineated across the plot to aid the crew in efficiently cruising the subplot.

7. All current mortality greater than 5.0 inches DBH was tallied. Information collected included DBH (by 1 inch classes), species, and pests. The height of the 1st, 3rd, and 6th tree in each diameter class was recorded. If the tree measured for height had defects which reduced total height then the next tree occurring in that diameter class was measured. Additional data collected included:

   a. The occurrence and distribution of root diseases within the subplot. Areas of root disease were measured (length and width).

   b. Five variable plots (40 BAF) were established using a Spiegel-Relaskop. One variable plot was established at the subplot center and one in each cardinal direction 1-chain from the center of the variable plot.

   c. Data collected on variable plots included tree species, DBH, height, whether live or dead, and pests (if any). Slope, aspect, and vegetation type were also noted.

Data Analysis

Data analysis was modified from a procedure outlined by White et al. 1983. Using established volume equations (Myers and Edminster, 1972), cubic foot volumes associated with each diameter class were estimated. Volumes on each subplot were then determined and the data expanded Forest-wide.

RESULTS AND DISCUSSION

An estimate of subalpine fir mortality on the San Juan National Forest is presented in Table 1. Since mortality was scattered over the entire spruce-fir type, the infested acreage listed is the same as host type - 363,300 acres. Annual volume loss is estimated at 2,286,200 cubic feet or 6.3 cubic feet per acre. This is equivalent to almost 200 times the harvest in 1984 of subalpine fir on the Forest. The western balsam bark beetle and root diseases were associated with 63 percent of the mortality. Armillaria mellea was found on 1.3 percent of the dead trees.

The area containing root disease is estimated at 38,400 acres or 10.6 percent of the forest type. This estimate compares to 15 percent of the commercial forest land in the Northern Rocky Mountain Region (Montana and Northern Idaho) affected by root diseases (Smith, 1984).

This survey technique appears to be adequate to estimate Forest-wide losses to root disease within an acceptable level of error; however, it is time-consuming and photomissions must be flexible to adjust to rapidly changing weather conditions in the mountains. At this time there are no plans to continue similar surveys for each of the Forests in the Rocky Mountain Region.

Table 1. Subalpine fir mortality on the San Juan National Forest in Colorado, 1982.

Land ownership class	Host type (Acres)	Infested area (Acres)	Number of dead trees	Annual volume loss (cu. ft.)	Area containing root disease (Acres)
National Forests	353,800	353,800	134,100	2,226,400	37,500
Other Federal Lands	---	---	---	---	---
State and private lands	9,500	9,500	3,700	59,800	900
Forest-wide total	363,300	363,300	137,800	2,286,200	38,400
Relative standard error	---	---	± 17.3%	± 14.0%	± 19.6%

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